

## Assured Resilience for Autonomous Systems, Phase I

Completed Technology Project (2018 - 2019)



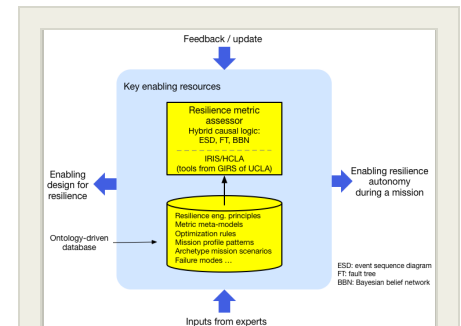
## Project Introduction

While automation technologies advance faster than ever, gaps of resilience capabilities between autonomous and human-operated systems have not yet been filled in proportion. Accordingly, ATAnalytics, in collaboration with The Center for Reliability and Resilience Engineering (CRRE) of The B. John Garrick Institute for the Risk Sciences at UCLA proposes to develop a methodology and toolkit for assured resilience of autonomous systems (ARAS). The central part of the ARAS methodology consists of two gap fillers: (1) an ontology-driven database supporting resilience engineering activities and resilience modeling, and (2) a resilience assessment and optimization employing a Hybrid Causal Logic (HCL) based software platform for resilience engineering support. The database includes resilience engineering principles, archetype mission scenarios, and metric meta models. With the HCL-based resilience assessor, a high-level model at the top layer enables resilience metrics to be defined at the mission-scenario level (or CONOPS level) and be subsequently mapped to the lower-level models to capture system specifics. Our innovation will be a significant step forward to resilience engineering standardization since (i) the database (a knowledge hub) and resilience models will be onboard resources enabling both design-for-resilience and onboard decision making for resilience assurance, and (ii) the HCL metrics-in-the-loop methodology is inherently generalizable for different levels of system abstraction, life-cycle, and mission phases.

## Anticipated Benefits

Excellent NASA application opportunities exist for the ARAS methodology and engineering tools. In particular, the results from this effort are most applicable to two types of space missions. One type is robotics missions such as NASA Europa Clipper mission to Jupiter's frozen moon. The other type is crewed missions to which ground support for fault management is not practicable due to the unacceptable transmission delay of commands from the earth, such as the future Moon-To-Mars missions.

The ARAS methodology and its tool implementation will have a wide application domain. One example type of application is military vehicles, such as fighters, long-range missiles, UAVs, and UGVs. In addition, our ARAS methodology and tools are highly applicable to self-driving automobiles and civil aviation industries of which safety ratings are the key. Other application areas include patient vital-sign monitoring and natural disaster alert systems for which failures mean loss of life.



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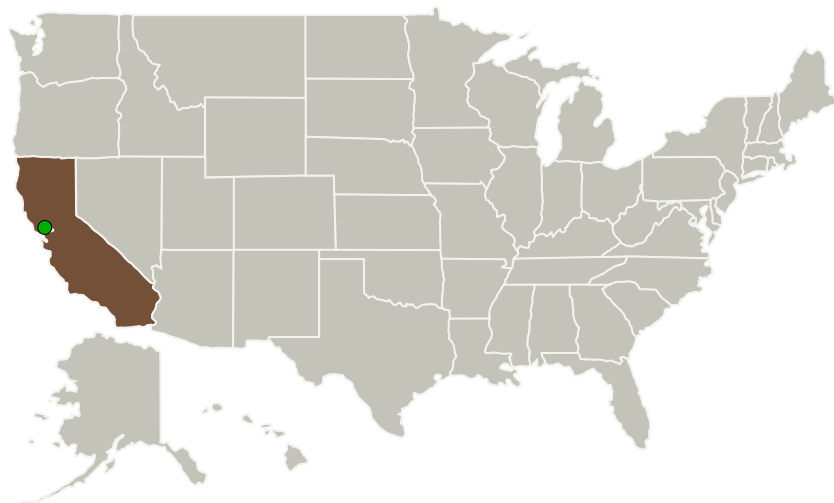
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
ATanalytics	Lead Organization	Industry Minority-Owned Business, Small Disadvantaged Business (SDB), Women-Owned Small Business (WOSB)	Santa Monica, California
● Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

## Primary U.S. Work Locations

California

## Project Transitions

**July 2018:** Project Start

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

ATanalytics

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

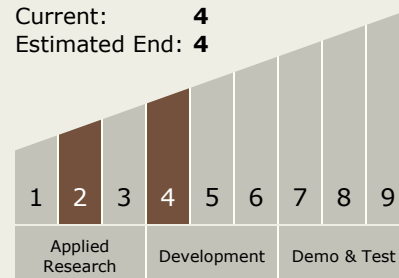
Carlos Torrez

**Principal Investigator:**

Ann Tai

## Technology Maturity (TRL)

Start: 2  
 Current: 4  
 Estimated End: 4



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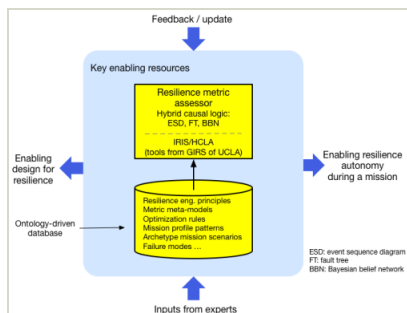


✓ **February 2019:** Closed out

## Closeout Documentation:

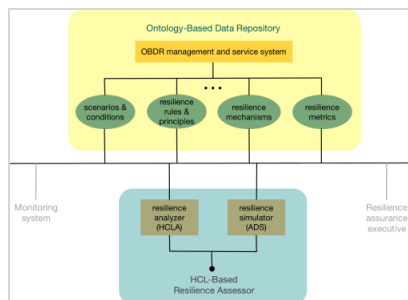
- Final Summary Chart(<https://techport.nasa.gov/file/141272>)

## Images



### Briefing Chart Image

Assured Resilience for Autonomous Systems, Phase I  
(<https://techport.nasa.gov/image/130804>)



### Final Summary Chart Image

Assured Resilience for Autonomous Systems, Phase I  
(<https://techport.nasa.gov/image/131047>)

## Technology Areas

### Primary:

- TX04 Robotic Systems
  - TX04.1 Sensing and Perception
    - TX04.1.1 Sensing for Robotic systems

## Target Destinations

Mars, Others Inside the Solar System